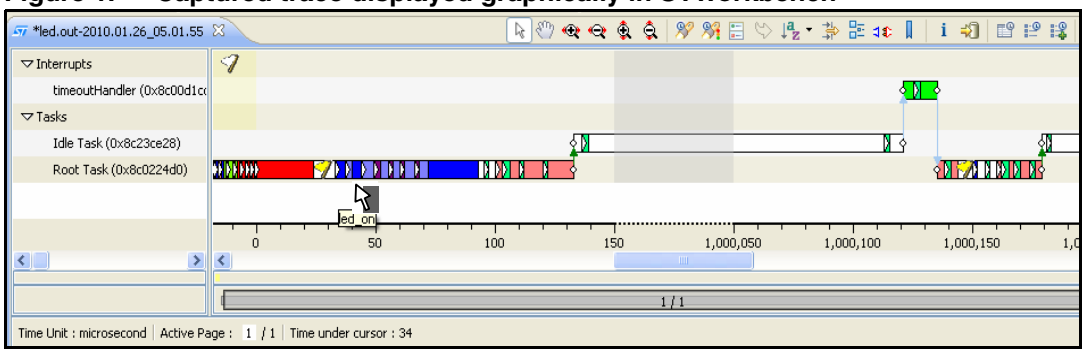
Application note

ST40 Micro Toolset user trace support

Introduction

As well as supporting the tracing of OS21 kernel activity and OS21 APIs, the ST40 Micro Toolset also supports tracing for user defined APIs and activities. These can all be viewed graphically using **STWorkbench**. *Figure 1* shows an example of a trace in which the mouse pointer is over a recorded call to a user API called `led_on()`.

Figure 1. Captured trace displayed graphically in STWorkbench



Support for tracing user defined APIs and activities was first introduced in the ST40 Micro Toolset R5.0.0. STMicroelectronics recommend that users use the latest **STWorkbench** release with the ST40 Micro Toolset.

This application note gives a brief guide to using this facility through a worked example. It also describes how this feature can be used in STAPI SDK to trace calls to the STAPI SDK API and events.

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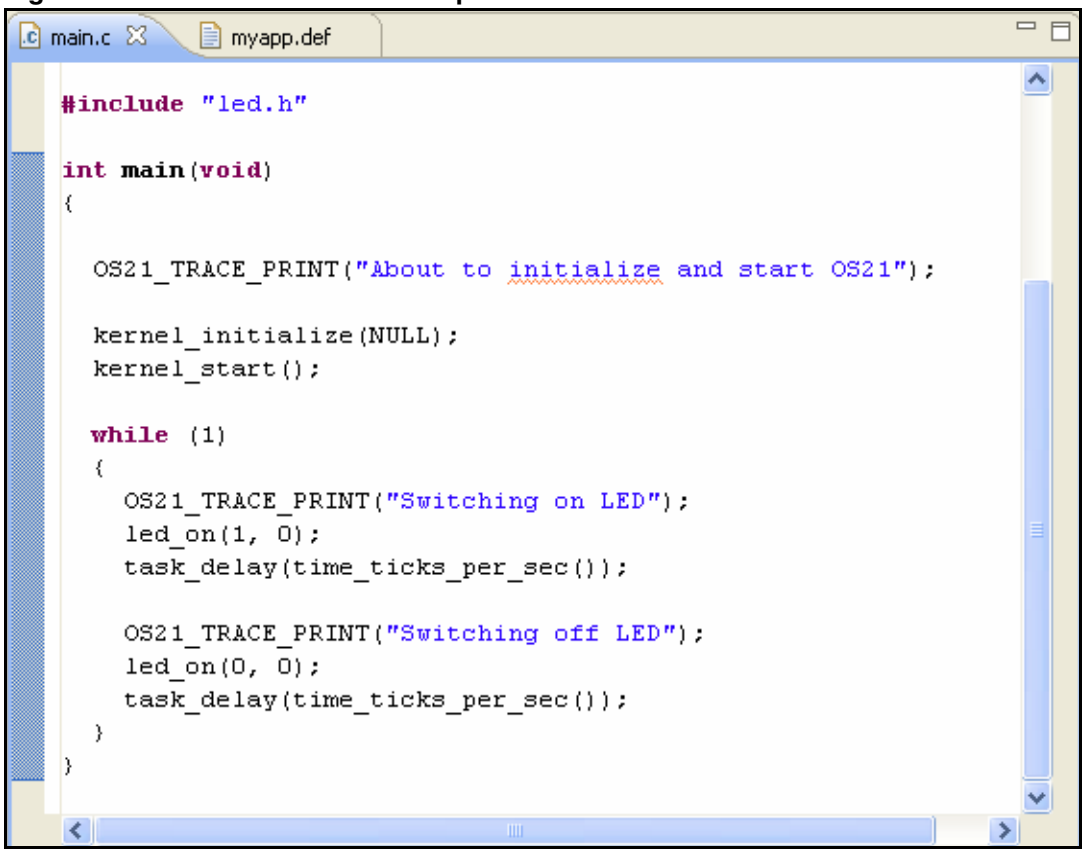
1 Example of performing a user API trace

1.1 Overview

The following example describes how support for User API trace is set up, and how the captured trace can be viewed in **STWorkbench**.

Figure 2 shows the **main.c** of the LED example in the **STWorkbench** editor.

Figure 2. main.c of the LED example



This application note describes how to trace calls to the function `led_on()`. In addition, the example shows a call to a function `OS21_TRACE_PRINT()`, which prints a string into the trace buffer.

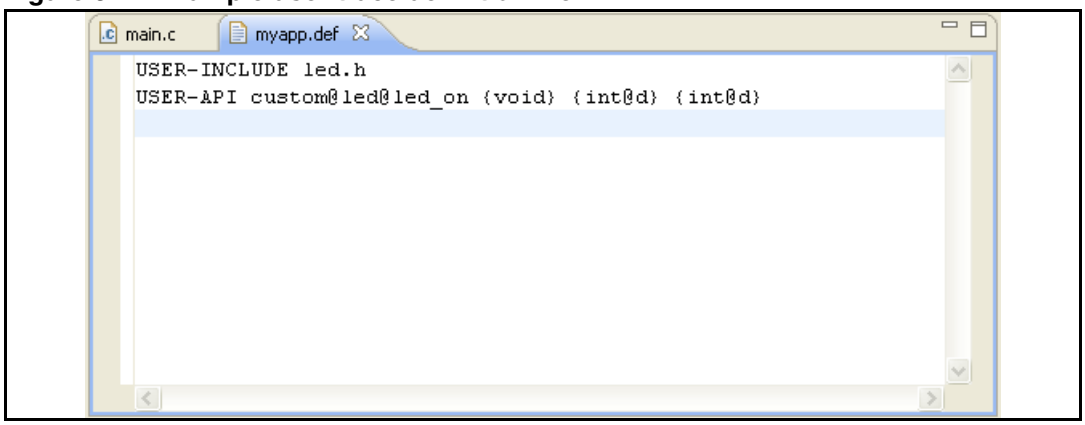
1.2 User trace definition file

To trace an application for OS21 kernel activity, OS21 APIs or both, instrumented versions of the OS21 libraries must be linked with the application. The same principles are also true for tracing user defined APIs and activities.

The first step is to write a user trace definition file, specifying the APIs and events to be traced. The Perl script **os21usertrace** uses this file to generate all the output files required to build a version of the application that is instrumented for tracing user APIs.

In *Figure 3*, the trace definition file **myapp.def** describes the function to trace, `led_on()`.

Figure 3. Example user trace definition file



The definition of `led_on()` indicates that the function has a return type of `void`, and accepts two parameters, both of which are 32-bit (double word) integers (as indicated by `{int@d}`).

Note: See the "OS21 Trace" chapter in the ST40 Micro Toolset user manual (7379953) for more information concerning the user trace definition file.

Using this file as input, the Perl script **os21usertrace** generates the following files:

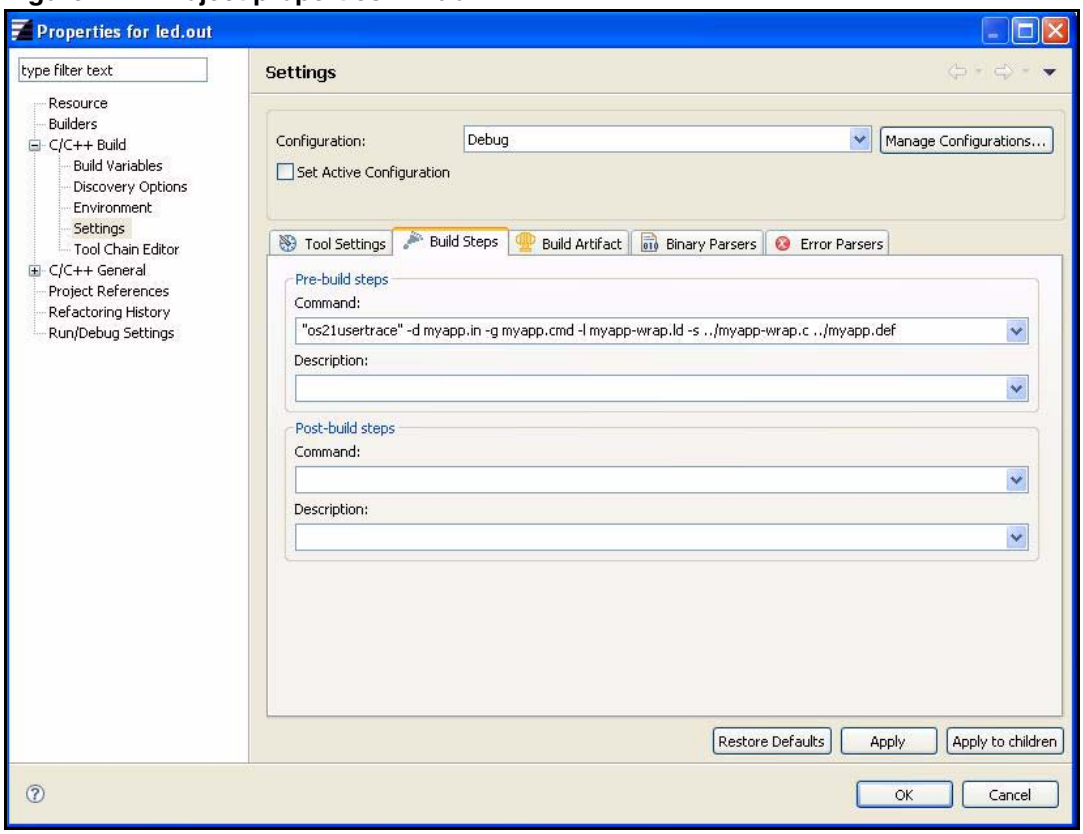
- a control file (for example, **myapp.in**)
- a GDB command script file (for example, **myapp.cmd**) to allow calls to `led_on()` to be captured and viewed in **STWorkbench's** trace view
- a linker script file (for example, **myapp-wrap.ld**) to pull in a instrumented version of `led_on()`
- a source file (for example, **myapp-wrap.c**) that wraps the function `led_on()` to provide the necessary instrumentation

Use the following command line to process the example trace definition file **myapp.def** of the LED example:

```
os21usertrace -d myapp.in -g myapp.cmd -l myapp-wrap.ld -s
../myapp-wrap.c ../myapp.def
```

This command line can be invoked directly from a command console, either by a user supplied makefile or by **STWorkbench**. If processing the command using **STWorkbench**, specify the command as a pre-build step. This is seen in the **Project Properties** window (see *Figure 4*).

Figure 4. Project properties window

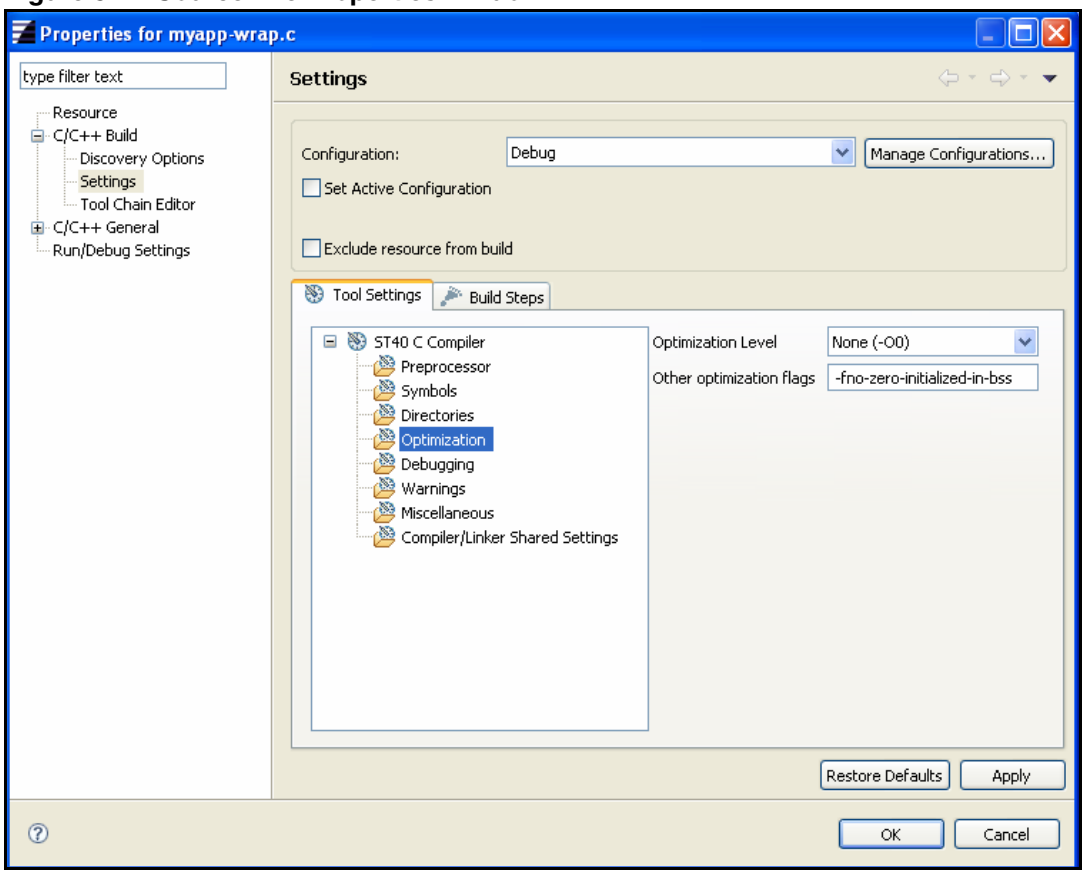


*Note: Windows requires double quotes around the invocation of the **os21usertrace** tool (as shown in Figure 4). On Linux, the double quotes are not required.*

1.3 Compiling the application

The application can be compiled as normal, with the exception of the generated source file (**myapp-wrap.c**), the file that wraps the function `led_on()` to provide the necessary instrumentation. This source file must be compiled with the optimization option `-fno-zero-initialized-in-bss`, which ensures that control data is initialized at the point when the application is loaded into memory. This is set up in **STWorkbench** by specifying the option in the **Properties** for this source file, as shown in *Figure 5*.

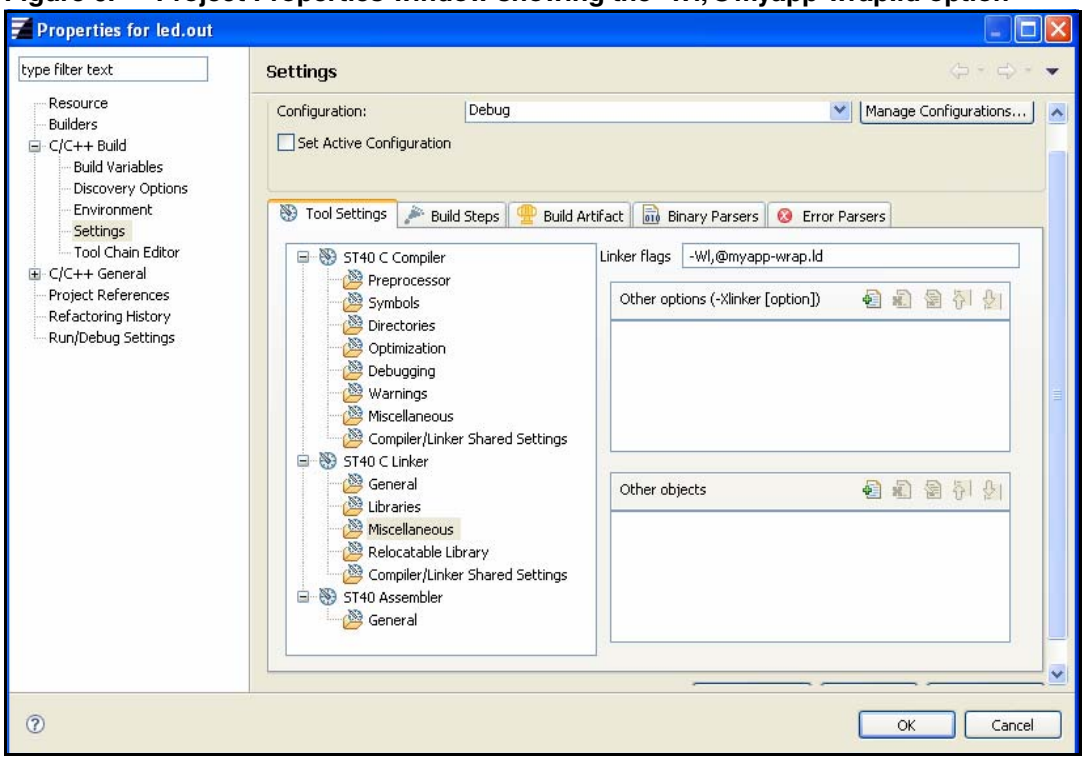
Figure 5. Source File Properties window



1.4 Linking the application

When the application has been compiled, the next step is to link it. The application is linked in the normal manner; however, to enable the application to be traced, remember to use the `–trace` linker option. The user can also use the `–trace-api` linker option to trace calls to the OS21 API together with all OS21 kernel activity. To trace the user API `led_on()`, the generated linker script file (**myapp-wrap.ld**) must be specified in order to link in the instrumented version of `led_on()`. This is done by adding the option `-Wl,@myapp-wrap.ld` to the linker command line. In **STWorkbench**, this is set up in the **Linker flags** field of the **Project Properties** window, as shown in *Figure 6*.

Figure 6. Project Properties window showing the -Wl,@myapp-wrap.ld option



When the build options have been set in **STWorkbench**, the example can be built. When building the application in **STWorkbench**, the operation generates the command lines shown in *Figure 7*.

Figure 7. Console window output when building the example

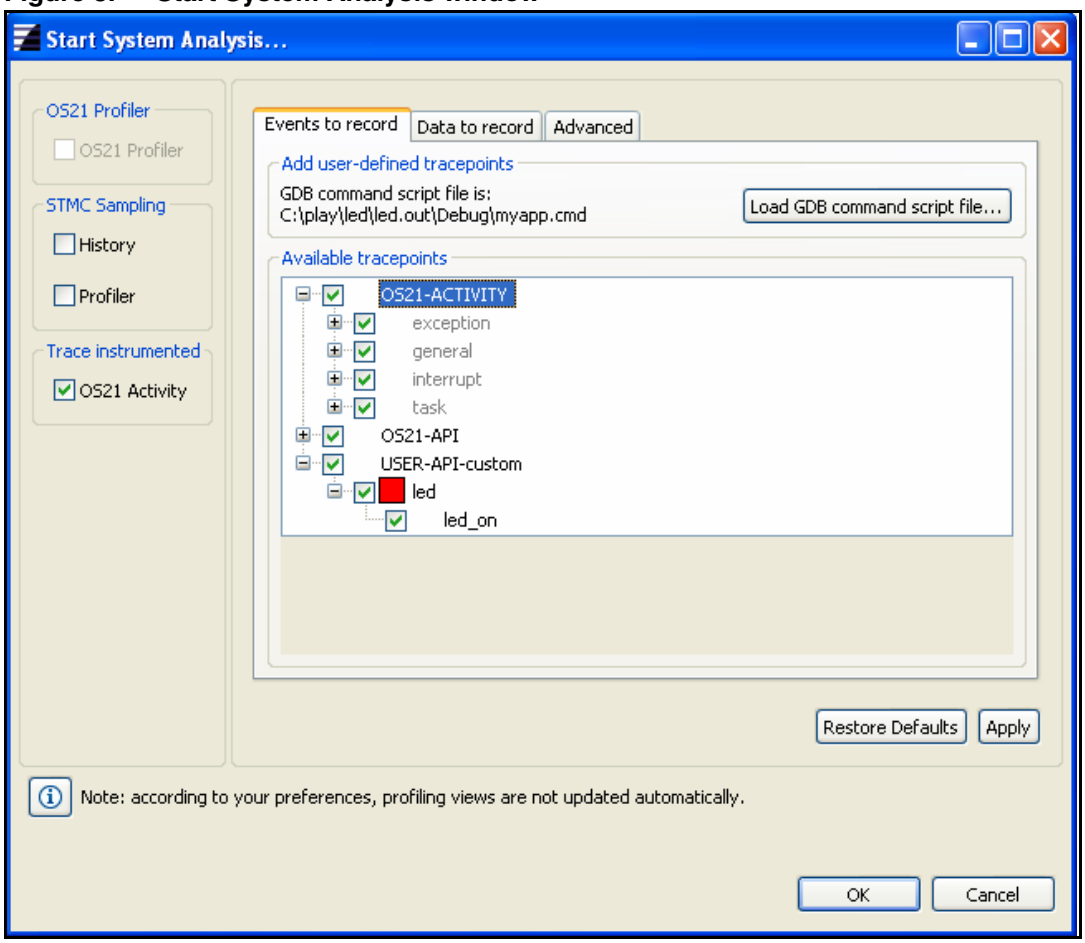
```
**** Build of configuration Debug for project led.out ****

make pre-build main-build
"os21usertrace" -d myapp.in -g myapp.cmd -l myapp-wrap.ld -s ../myapp-wrap.c ../myapp.def
' '
'Building file: ../led.c'
'Invoking: ST40 C Compiler'
sh4gcc -D__mb680sti7105__ -O0 -g -Wall -c -fmessage-length=0 -mboard=mb680sti7105
-mruntime=os21 -ml -trace -trace-api -MMD -MP -MF"led.d" -MT"led.d" -o"led.o" "../led.c"
'Finished building: ../led.c'
' '
'Building file: ../main.c'
'Invoking: ST40 C Compiler'
sh4gcc -D__mb680sti7105__ -O0 -g -Wall -c -fmessage-length=0 -mboard=mb680sti7105
-mruntime=os21 -ml -trace -trace-api -MMD -MP -MF"main.d" -MT"main.d" -o"main.o"
"../main.c"
'Finished building: ../main.c'
' '
'Building file: ../myapp-wrap.c'
'Invoking: ST40 C Compiler'
sh4gcc -D__mb680sti7105__ -I. -O0 -fno-zero-initialized-in-bss -g -Wall -c
-fmessage-length=0 -mboard=mb680sti7105 -mruntime=os21 -ml -MMD -MP -MF"myapp-wrap.d"
-MT"myapp-wrap.d" -o"myapp-wrap.o" "../myapp-wrap.c"
../myapp-wrap.c:8:17: warning: led.h: No such file or directory
../myapp-wrap.c: In function 'user_api_set_group_custom_class_enable':
../myapp-wrap.c:38: warning: enumeration value 'user_api_group_custom_class_EOF' not
handled in switch
../myapp-wrap.c: In function 'user_api_set_group_enable':
../myapp-wrap.c:54: warning: enumeration value 'user_api_group_EOF' not handled in switch
'Finished building: ../myapp-wrap.c'
' '
'Building target: led.out'
'Invoking: ST40 C Linker'
sh4gcc -Wl,@myapp-wrap.ld -mboard=mb680sti7105 -mruntime=os21 -ml -trace -trace-api
-o"led.out"  ./led.o ./main.o ./myapp-wrap.o
'Finished building target: led.out'
' '
```

This is the output seen in **STWorkbench's** console window. If you are not using **STWorkbench** to build the example, then these commands can be entered in a command console directly or can be used to write a user supplied makefile.

1.5 Tracing the application

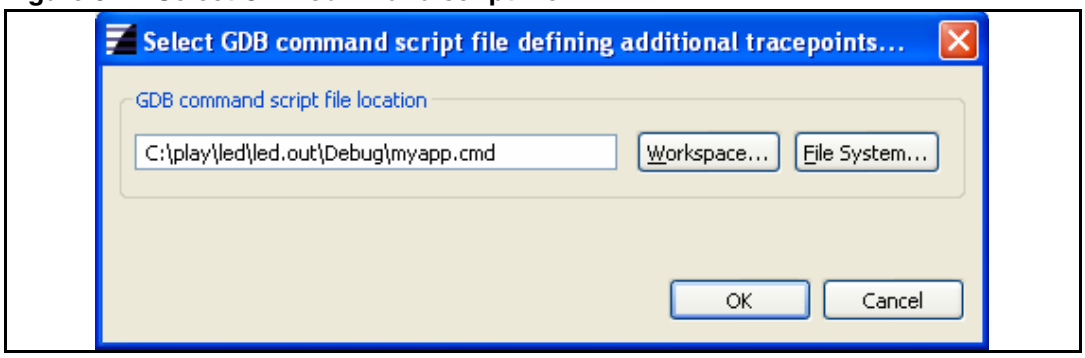
When the application has been built, it can then be debugged and traced with the **STWorkbench** debugger. When the **STWorkbench** debugger has been launched, start a trace on the application by clicking the **Start New Analysis** icon, found in the **Debug** window. This opens the **Start System Analysis** window (see *Figure 8*).

Figure 8. Start System Analysis window



In this window you can select which OS21 kernel activity events and which OS21 APIs to record. To include user defined API in the trace, the GDB command script file generated by the Perl script **os21usertrace** must be loaded. This is done by clicking on the button **Load GDB command script file…** and selecting the appropriate file (see *Figure 9*).

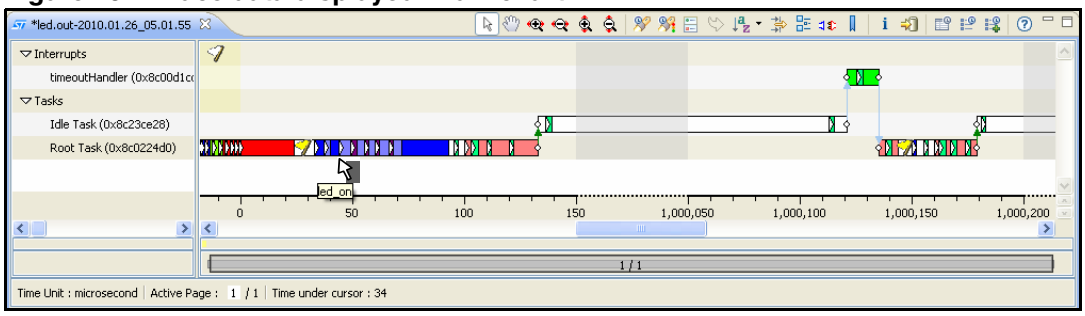
Figure 9. Select GDB command script file



When the command script has been loaded, select which User API to record. Click on OK to start tracing the application.

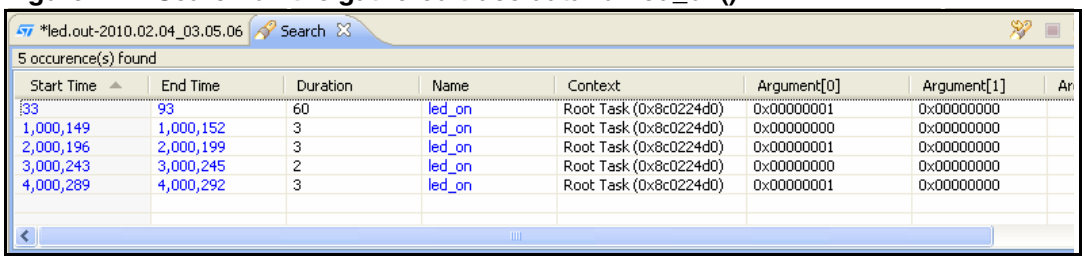
To stop gathering trace data, click on the **Stop Analysis** button in the **Debug** window. **STWorkbench** immediately displays the recorded trace data in a chart (see *Figure 10*).

Figure 10. Trace data displayed in a T-chart



Included in the trace records are calls to `led_on()`, as shown under the mouse pointer in *Figure 10*. It is also possible to search for these calls in the accumulated raw data using the trace search facility. This is selected by clicking on the relevant icon found at the top of the window. *Figure 11* shows example output from trace search.

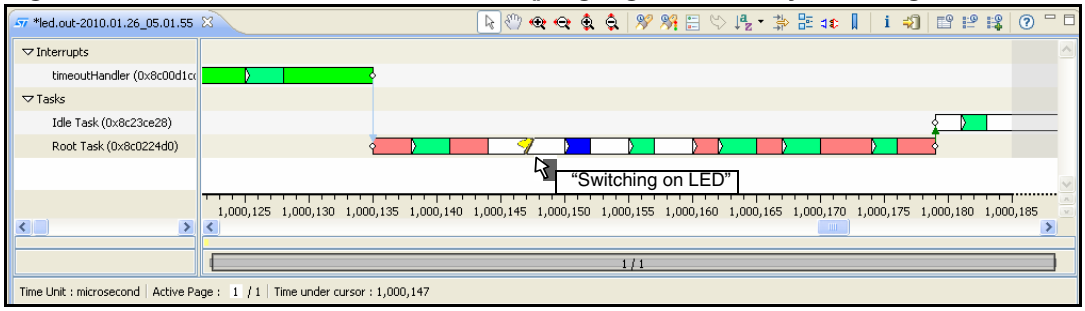
Figure 11. Search on the gathered trace data for led_on()



Start Time	End Time	Duration	Name	Context	Argument[0]	Argument[1]
33	93	60	led_on	Root Task (0x8c0224d0)	0x00000001	0x00000000
1,000,149	1,000,152	3	led_on	Root Task (0x8c0224d0)	0x00000000	0x00000000
2,000,196	2,000,199	3	led_on	Root Task (0x8c0224d0)	0x00000001	0x00000000
3,000,243	3,000,245	2	led_on	Root Task (0x8c0224d0)	0x00000000	0x00000000
4,000,289	4,000,292	3	led_on	Root Task (0x8c0224d0)	0x00000001	0x00000000

Finally, calls to the function `OS21_TRACE_PRINT()`, which prints a user-defined string into the trace buffer, are highlighted using a yellow flag. See *Figure 12* for an example.

Figure 12. Calls to OS21_TRACE_PRINT() highlighted with a yellow flag



2 User API trace and events in STAPI SDK

2.1 Overview

An example written by the ST40 Micro Toolset team is available. When applied to STAPI SDK v0.23 onwards, it provides the `OS21_TRACEUSER` make variable. When this make variable is set, it prepares the STAPI SDK application so that a subset of STAPI SDK API and events can be traced. The framework of this example can be customized by the user to extend or reduce the number of STAPI SDK API and events that can be traced.

2.2 Installing the example

The example, providing the `OS21_TRACEUSER` make variable in STAPI SDK, is available on request by contacting your FAE or ST customer contact.

To apply the example simply unpack it over the top of the STAPI SDK installation. A **readme.txt** file is also unpacked at the top directory, and this explains which STAPI SDK files have been modified and which files have been added.

If the `OS21_TRACEUSER` make variable is not set, then STAPI SDK can be built and will run as normal. There are no side-effects to the normal behavior of STAPI SDK after this example has been applied.

2.3 Building STAPI SDK for user API trace and events

As standard, STAPI SDK already provides the make variables listed in *Table 1* to allow the STAPI SDK application to be profiled using the OS21 Profiler and traced for OS21 events (task creation, interrupt handler installed, context switch and so forth) and OS21 API calls.

Table 1. Default Make variables in STAPI SDK

Make variable	Description
`OS21_TRACE`	Link the application with the `-trace` option to enable OS21 trace support.
`OS21_TRACEAPI`	Link the application with the `-trace -trace-api -trace-api-no-time` options to initialize OS21 trace support and OS21 API tracing, except for the time functions.
`OS21_PROFILER`	Link the application with the `-profiler` option to initialize OS21 profiler support.

The example extends this list by providing the additional `OS21_TRACEUSER` make variable.

When building the STAPI SDK application so that a subset of STAPI SDK API and events can be traced, both the make variables `OS21_TRACEUSER` and `OS21_TRACE` must be set. The make variable `OS21_TRACEAPI` can be set to also include calls to the OS21 API in the trace.

Normally the STAPI SDK application is not be prepared for OS21 profiling at the same time as OS21 tracing, although this is possible.

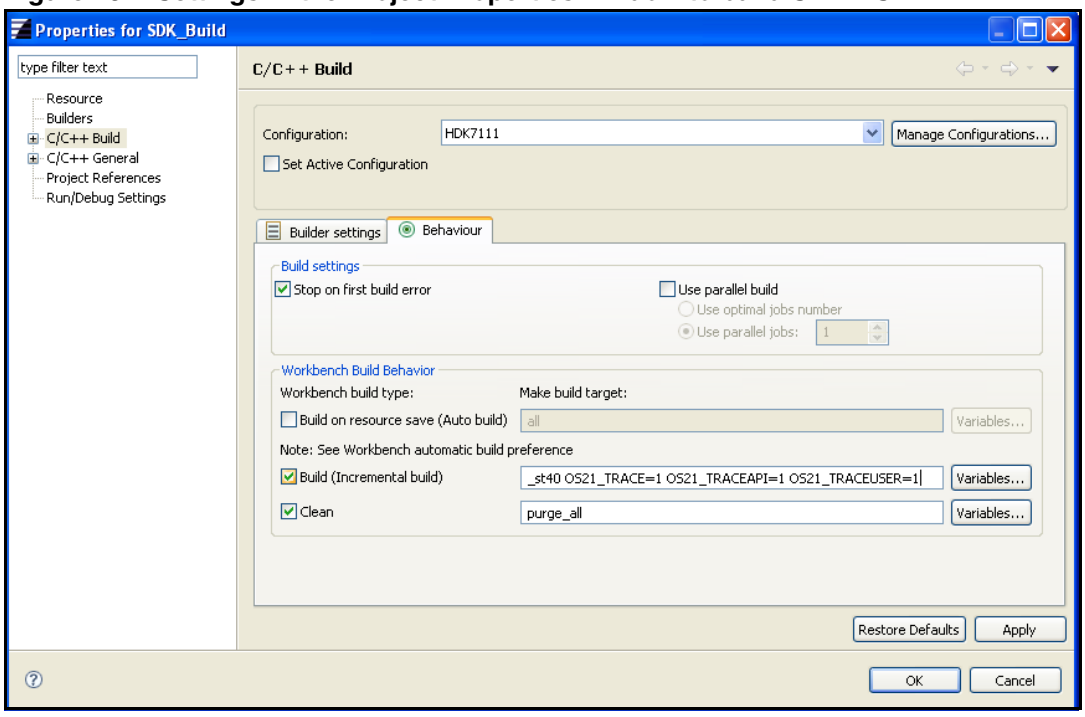
Use the following command line to build STAPI SDK to prepare it so that a subset of STAPI SDK API and events can be traced along with OS21 events and API calls.

```
make apilib all OS21_TRACE=1 OS21TRACEAPI=1 OS21_TRACEUSER=1
```

If STAPI SDK is being built in **STWorkbench**, then enter the following in the **Build** command field of the **Project Properties** window:

```
apilib all build_start_script_connect_st40 OS21_TRACE=1
OS21TRACEAPI=1 OS21_TRACEUSER=1
```

Figure 13. Settings in the Project Properties window to build STAPI SDK



2.4 Tracing the STAPI SDK application

When the STAPI SDK application has been built, it can be debugged and traced in the **STWorkbench** debugger.

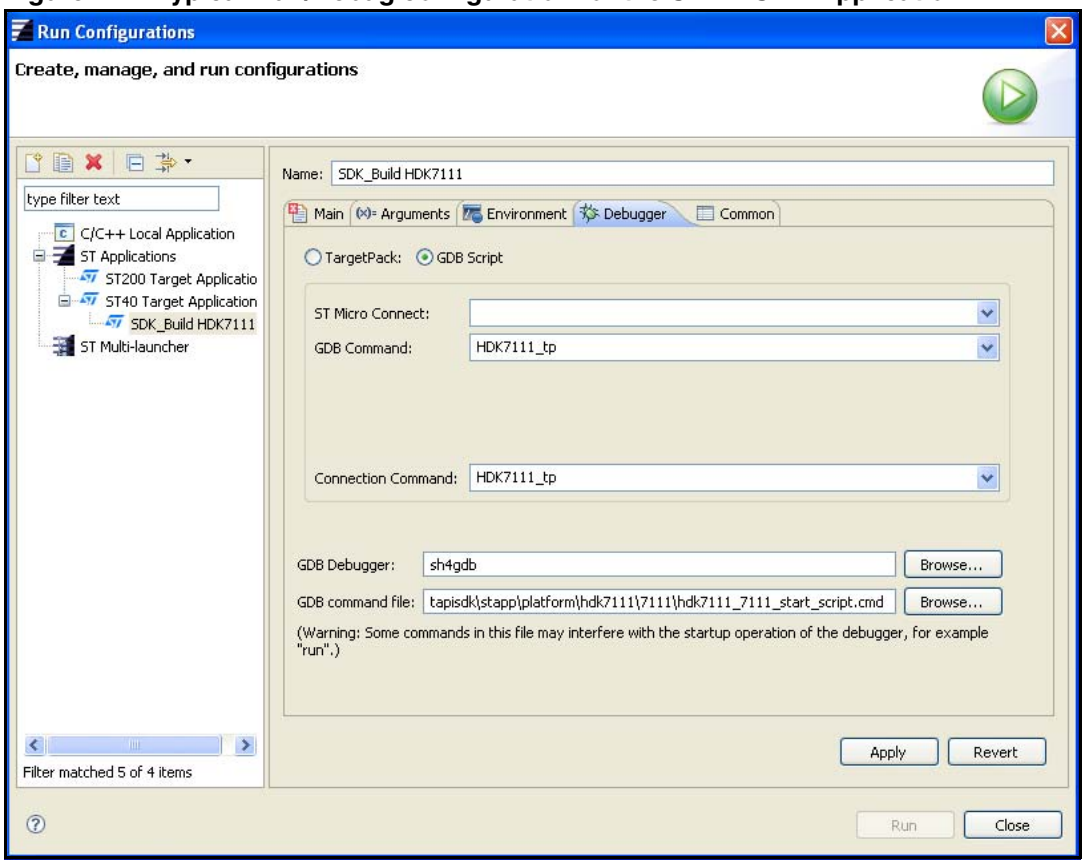
STAPI SDK can launch the **STWorkbench** debugger using the following command:

```
gmake debug STWORKBENCH=1
```

Alternatively, if STAPI SDK has been built in **STWorkbench**, then the debugger can be launched when a debug configuration has been created.

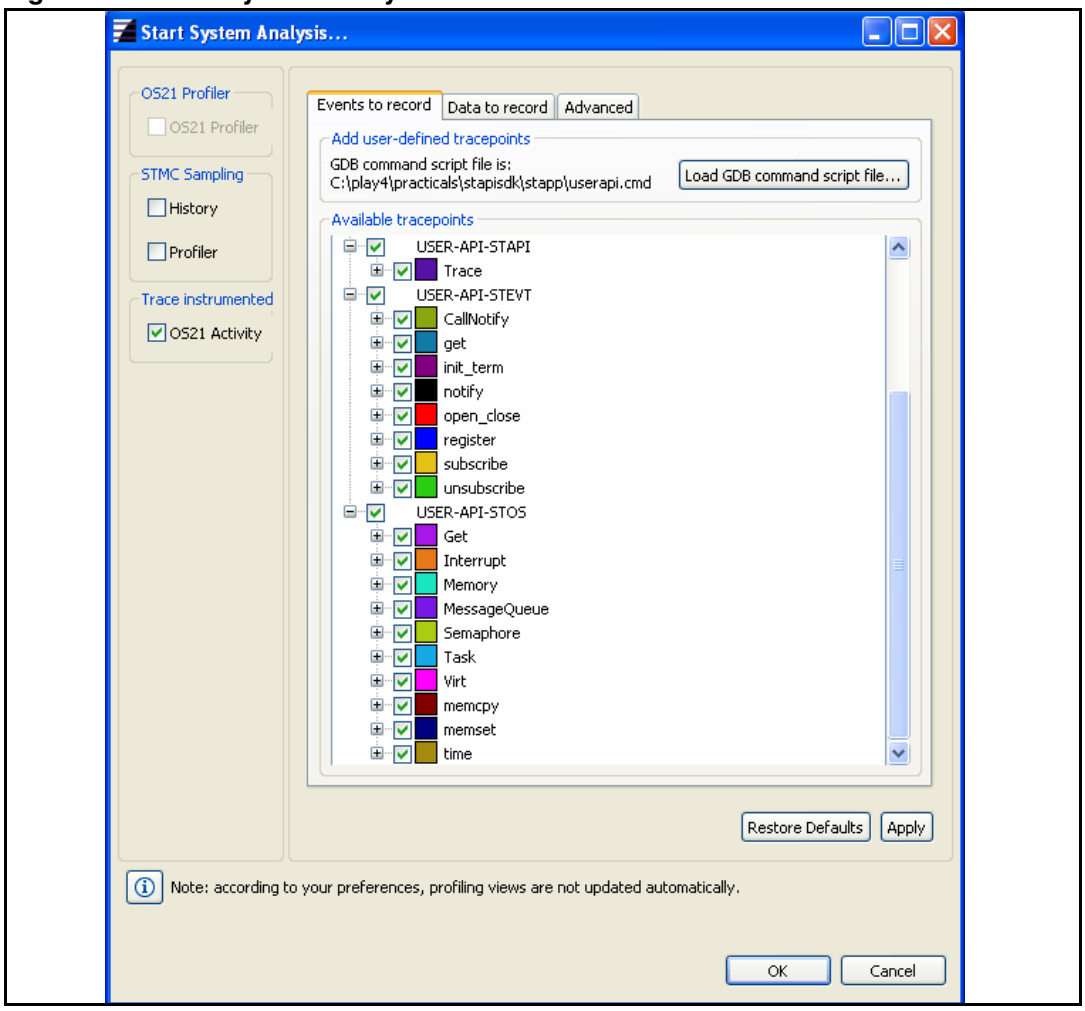
Figure 14 shows a typical Run or Debug configuration for the STAPI SDK application.

Figure 14. Typical Run/Debug configuration for the STAPI SDK Application



After launching the **STWorkbench** debugger, start a trace on the application by clicking on the **Start New Analysis** icon, found in the **Debug** window. This opens the **Start System Analysis** window, as shown in *Figure 15*.

Figure 15. Start System Analysis Window

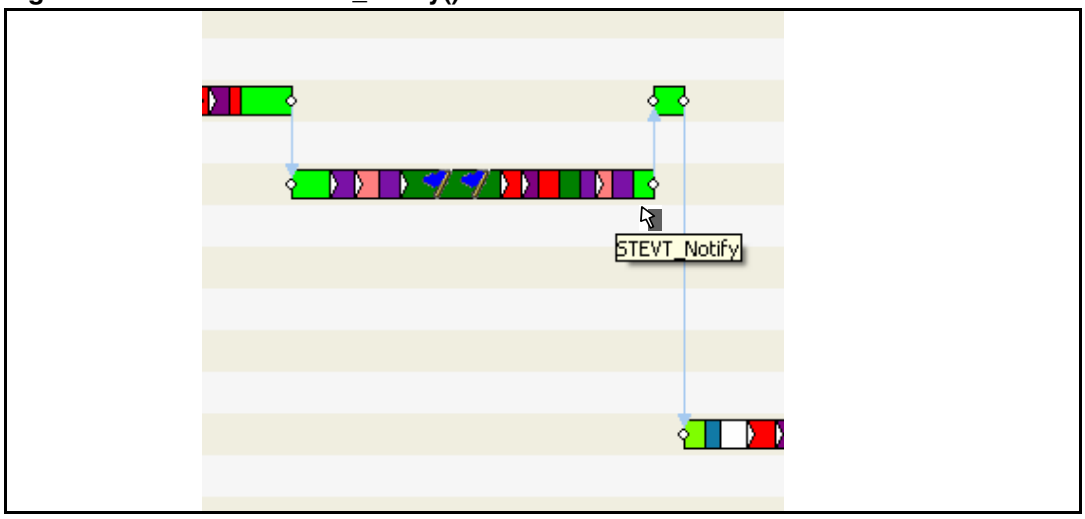


In this window, select which OS21 kernel activity events and which OS21 APIs to record. To include user defined API in the trace, load the GDB command script file `stapp/userapi.cmd`. To do this, click on the button **Load GDB command script file...** .

When this has been done, select in **Available Tracepoints** which STAPI SDK API and events to record. Click on OK to start tracing the application.

To stop gathering trace data, click on the **Stop Analysis** button of the **Debug** window. As soon as tracing stops, **STWorkbench** displays the recorded trace data in a chart (see *Figure 16*).

Figure 16. A call to STEVT_Notify() is included in the trace



Included in the trace records are calls to the sub-set of STAPI SDK API and events.

3 References

For in depth information on OS21 trace and User API trace features, refer to the “OS21 Trace” chapter of the *ST40 Micro Toolset User Manual* (7379953). Also refer to **STWorkbench Help** for assistance on getting started using these facilities in **STWorkbench**.

4 Revision history

Table 2. Document revision history

Date	Revision	Changes
26-Apr-2010	A	Initial release.

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